PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

10 DEC 2004

Applicant's or agent's file reference M02B129/MW	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB 03/02464	International filing date *(day/month/year)* 09.06.2003	Priority date *(day/month/year)* 11.06.2002
International Patent Classification (IPC) or both national classification and IPC C22C33/04		
Applicant THE BOC GROUP PLC et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09.12.2003	24.09.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Catana, C Telephone No. +49 89 2399-7369

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB 03/02464

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1, 2, 4, 5, 7-16	as originally filed
3, 6	received on 12.03.2004 with letter of 11.03.2004

Claims, Numbers

1-21	received on 12.03.2004 with letter of 11.03.2004

Drawings, Sheets

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☒ the claims, Nos.: 22

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-21
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-21
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-21
	No:	Claims	

2. Citations and explanations

   see separate sheet

The method of refining a ferroalloy (i.e. ferrochromium, ferromanganese) using injection of particulate materials to be included in the refined alloy using a supersonic gas jet shrouded by another supersonic gas jet is not disclosed or does not appear obvious in the light of available prior art documents.

The method as defined in claim 1 enhances the processes of ferroalloys refining (increase of productivity, less wear of lining, better confinement of particles in the melt) (see page 4, 1st and 2nd par.; paragraph bridging pages 6 and 7).

The subject-matter of claim 1 and of the dependent claims thereof fulfil the conditions of Art. 33(2)-33(3) PCT.

by directing a jet of neutral gas entraining carbon against the surface of the melt at a supersonic velocity while oxygen for refining purposes is directed at the surface from separate and non-shrouding jets and the metal is bottom blown by neutral gas to prevent excessive foaming of the slag.

JP-A-61284512 discloses the production of high chrome steel by mixing chrome ore and coke powders in a blowing nozzle and blowing the mixture into the firing point of the molten iron both to melt and reduce the chrome ore.

GB-A-2 054 655, GB-A-2 122 649, and JP-A-58207313 relate to basic oxygen steel making processes in which molten metal is top-blown with oxygen and bottom blown with a different gas. Solids may be introduced with the gases.

JP-A-61106744A relates to the introduction of oxygen and solids into a furnace through tuyeres during the manufacture of stainless steel.

According to the present invention there is provided a method of refining a ferroalloy, including the step of blowing molecular oxygen or a gas mixture including molecular oxygen into a melt of the ferroalloy, wherein a metallurgically acceptable particulate material is introduced from above into the melt, the particulate material being carried into the melt in a first supersonic gas jet which travels to the melt shrouded by a second gas jet, and the second gas jet is a supersonic gas jet.

Preferably, only part of the molecular oxygen is supplied from below the surface of the melt in the method according to the invention.

By the term "ferroalloy" as used herein is meant an alloy which contains at least 10% by weight of iron. Typically, the ferroalloy contains at least 30% by weight of iron.

The metallurgically acceptable particulate material acts as a coolant and is preferably selected from metals that are to be included in the refined alloy, alloys of such metals, and oxides of such metals, and mixtures thereof.

performed, they would not penetrate the surface of the molten ferrochrome and would therefore have at most only a negligible reducing action. Analogous advantages can be achieved by employing as the metallurgically acceptable particulate material fine particulate charge chrome that is also obtained as a waste material in the production of the crude ferrochromium.

By introducing the metallurgically acceptable particulate material into the melt from above in a supersonic first gas jet, however, the momentum of the gas jet is such as to be able to penetrate both a slag layer on top of the surface of the molten ferroalloy being refined by the method according to the invention and the surface itself. By shrouding a first gas jet with the second jet, the rate of reduction in velocity that naturally occurs when a gas jet moves through a still atmosphere is not nearly so marked.

The second gas jet is also a supersonic jet. More preferably, the first gas jet is ejected from a first Laval nozzle at a first supersonic velocity and the second gas jet is ejected from a second Laval nozzle at a second supersonic velocity, the second supersonic velocity preferably being from 10% less than the first supersonic velocity to 10% greater than the first supersonic velocity. Both the first supersonic velocity and the second supersonic velocity are preferably in the range of Mach 1.5 to Mach 4, more preferably in the range of Mach 2 to Mach 3.

Several advantages arise from the use of a supersonic second gas jet. First, the rate of decay of the first gas jet tends to less than when a subsonic first gas jet is employed. Accordingly, the first gas jet can be allowed to travel a greater distance before impinging upon the slag layer or the surface of the melt. The rate of damage to the Laval nozzles caused by the splashing metal or slag can thus be kept to an acceptable level. Secondly, the velocity of the second jet can be selected such that it too is able to penetrate the slag layer and the surface of the molten metal. Accordingly, any particles migrating from the first jet to the second jet are still largely carried into the molten metal. Thirdly, by forming the first and second jets at similar

CLAIMS

1. A method of refining a ferroalloy; including the step of blowing molecular oxygen or a gas mixture including molecular oxygen into a melt of the ferroalloy, wherein a metallurgically acceptable particulate material is introduced from above into the melt, the particulate material being carried into the melt in a first supersonic gas jet which travels to the melt shrouded by a second gas jet, and the second gas jet is a supersonic gas jet.

2. A method according to claim 1, wherein the metallurgically acceptable particulate material is selected from metals that are to be included in the refined alloy, alloys of said metals, and oxides of said metals, and mixtures thereof.

3. A method according to claim 1 or claim 2, wherein the ferroalloy contains at least 30% by weight of iron.

4. A method according to any one of the preceding claims, wherein the ferroalloy is ferrochrome and the metallurgically acceptable particulate material comprises an oxide of chromium.

5. A method according to claim 4, wherein the oxide of chromium is chromite.

6. A method according to any one of the preceding claims, wherein the metallurgically acceptable particulate material comprises ferrochrome.

7. A method according to any one of claims 1 to 3, wherein the ferroalloy is a stainless steel and the metallurgically acceptable particulate material is an oxide of chromium.

8. A method according to claim 1 or claim 2, wherein the ferroalloy is ferromanganese and the metallurgically acceptable particulate material is an oxide of manganese.

9. A method according to any one of the preceding claims, in which the metallurgically acceptable particulate material is introduced into the melt in fine particulate form.

10. A method according to claim 9, wherein the mean particle of the metallurgically acceptable particulate material is 1 mm or less.

11. A method according to any one of the preceding claims, wherein the gas that forms the first gas jet is an oxidising gas, a non-oxidising gas, or a mixture of an oxidising gas and a non-oxidising gas.

12. A method according to claim 11, wherein the oxidising gas is oxygen.

13. A method according to claim 11 or claim 12, wherein the non-oxidising gas is one or both of argon and steam.

14. A method according to any one of the preceding claims, wherein the second gas jet is formed of burning gases.

15. A method according to any one of the preceding claims, in which the first gas jet is ejected from a first Laval nozzle at a velocity in the range of Mach 1.5 to Mach 4 and the second gas jet is ejected from a second Laval nozzle at a velocity also in the range of Mach 1.5 to Mach 4.

16. A method according to claim 15, wherein the first and second Laval nozzles form part of a metallurgical lance comprising an axial first gas passage terminating at its outlet and in the first Laval nozzle, a shrouding gas passage about the main gas passage terminating at its outlet end in the second Laval

nozzle, and a particulate material transport passage having an axial outlet which communicates with the first Laval nozzle.

17. A method according to claim 16, wherein the said axial outlet terminates in the divergent part of the first Laval nozzle.

18. A method according to claim 16 or claim 17, wherein the shrouding gas passage comprises a combustion chamber.

19. A method according to any one of the preceding claims, wherein the metallurgically acceptable particulate material is introduced into the melt continuously during a first part of a refining operation.

20. A method according to claim 19, in which the first gas jet comprises oxygen and introduction of the first gas jet into the melt continues after introduction of the metallurgically acceptable particulate material into the melt has ceased.

21. A method according to claim 20, in which introduction of the first gas jet into the melt ceases before the end of the refining operation.